



SwitchedGator

User Manual



SwitchedGator User Manual

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- Although every effort has been made to ensure the accuracy of this manual, if you note any points that are unclear or incorrect, please contact Technical support and sales so we can improve customer satisfaction
- Read the instruction manuals for any other products that you are using with this product (a computer or other peripheral equipment)
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The contents of this document have been carefully written and checked for accuracy. However, no warranty is provided on the accurateness, completeness or correctness of the information provided in this documentation.

Patents:

The proprietary configuration of the Gator working principle is patented under P99880NL00 and P99880US00. These patents are fully owned by Technobis Fibre Technologies.

Contents

1	SAFETY	5
2	PRODUCT SPECIFICATION	6
2.1	TECHNICAL SPECIFICATIONS.....	6
2.1.1	Optical performance.....	6
2.1.2	General specifications.....	6
2.1.3	Environmental specifications.....	7
2.1.4	Recommended FBG specifications	7
2.2	PRODUCT OVERVIEW	8
2.2.1	Front panel	8
2.2.2	Back panel	9
3	GETTING STARTED.....	10
3.1	HARDWARE INSTALLATION	10
3.2	SOFTWARE INSTALLATION	10
3.3	UNIT CONVERSION.....	11
4	SOFTWARE GUIDE.....	12
4.1	DEMO SOFTWARE	12
4.1.1	Settings.....	13
4.1.2	LED Panel Indications	13
4.1.3	Plot Options	14
4.1.4	Data Storage Format	14
4.2	PROGRAMMER'S GUIDE	15
4.2.1	USB Data output format	15
4.2.2	Sensor status word.....	15
4.2.3	Sensor data (1-8) words	16

1 Safety

Your safety may be compromised if you do not use the product in accordance with the instructions given in this document.

Laser safety

The Gator product comprises a broadband infrared light source, which is invisible to the human eye. Although intrinsically safe (Class 1, $P_{out} < 10 \text{ mW}$), it is advised not to look into the fiber-optic connections or the exit facet of a connected fiber.

The Gator product is intended for use in fiber-optic systems solely, i.e. intended for FBG sensing. It is not to be used in combination with other sensing equipment or fiber-optic telecommunication networks.

Electrical safety

This product has been tested, validated and qualified with the power adapter provided. To avoid injury, do not use any other means of power supply or other type of power adapter in combination with the Gator.

The product is not designed for outdoor use. To avoid the possibility of injury, do not expose the product to rain or excessive moisture, nor operate it in the presence of flammable gases or fumes.

2 Product Specification

2.1 Technical specifications

The SwitchedGator is a high-performance Fiber Bragg Grating interrogator, based on state-of-the-art technology such as integrated photonics and low noise electronics. It is intended for general use in fiber-optic sensing and testing. This chapter describes the SwitchedGator product specifications.

2.1.1 Optical performance

- Wavelength range 1515 - 1585 nm
- Wavelength stability 5 pm (steady state environment)
- Sampling speed 1 kHz , 5 kHz, 10 kHz, 19.23 kHz (*standard options*)
- Resolution < 1pm/bit, typically 0.275 pm/bit
- Noise Level $\sigma < 1 \text{ pm}^*$
- Channels 1
- FBGs / channel 1 – 8
- Dynamic range / sensor 4000 $\mu\epsilon$ *

** The precision of the SwitchedGator in terms of FBG interrogation is dependent on the sampling frequency and specifications of the FBG sensor connected. Under the conditions defined below, the specification can be met.*

2.1.2 General specifications

- Dimensions 110 x 130 x 47 mm
- Weight 540 grams
- Power consumption < 10 W ($\approx 5 \text{ W @}25^\circ\text{C}$)
- Optical connection FC/APC, SMF
- Data output USB 2.0

2.1.3 Environmental specifications

The product has been tested under the following environmental conditions:

- Operational Temperature range -20 ... +55 °C
- Storage Temperature range -40 ... +85 °C
- Degree of Protection IP 20 (EN/IEC 60529)

2.1.4 Recommended FBG specifications

In order to obtain most from your sensing system, we recommend the following specification for the FBG sensor central wavelengths:

- 1-8 sensors in the specified wavelength range of 1515-1585 nm
(including dynamic range extrema!), **spacing > 9 nm apart advised**
 - Example CW: 1518 nm, 1527 nm, ... , 1581 nm
 - Minimal spacing between FBGs should be >4.5 nm at all time. (incl. the dynamic range). The system will give an error if two sensors are too close together.
- SMF 28e fiber as standard
- High reflectivity FBG (R=0.5-0.99)
- FWHM of sensor, 150 - 400 pm
- Polarization dispersion < 5 pm
- <- 15 dB side modes, request apodization for suppression

Other FBG specifications might work, but specifications are not guaranteed. For example, sensitivity levels can be customized in settings to work for low reflectivity FBGs (but not different for individual optical channels). Please contact Technobis for support in choosing a suitable range and FBG configuration.

2.2 Product Overview

2.2.1 Front panel



Figure 4: Image of the SwitchedGator front panel, with a power switch on the left.

Table 1: SwitchedGator System status (orange)

Status LED indications	LED mode	Frequency	Duty Cycle
System is powered on	On	-	-
SSI running mode	Blinking	0.5 Hz	50%
TEC temperature not ok or electronics temperature out of range	Flash	2 Hz	12,5%

* Power cycle required

Table 2: SwitchedGator SLED status (blue)

Status LED indications	LED mode	Frequency	Duty Cycle
Light source off	Off		
Light source on	On		

2.2.2 Back panel



Figure 5: Image of the SwitchedGator back panel

Connection	Description
Power	LEMO power plug connection. Only use the power adapter supplied.
Data	USB 2.0 connection for data transfer. See Section 4.2 for details of communication.
FC/APC (8x)	Sensor fiber connection. Always leave the dust protection cap on when no fiber is connected. Dust and dirt can permanently damage the fiber facet.

3 Getting started

The SwitchedGator is a plug-and-play system. Follow these simple steps to get started.

3.1 Hardware Installation

WARNING: Only use the supplied power adapter with your SwitchedGator product. Technobis is not liable for inappropriate use.

Use the USB cable (USB 2.0 AB patch cord) provided to connect to a PC or laptop in order to obtain the data generated from the SwitchedGator.

The SwitchedGator is equipped with FC/APC standard fibre connectors, suitable for standard telecom SMF 28e fiber. Functionality with other fibre types is not specified. Make sure that the inserted connection is clean with each use as damage induced to the facet can be permanent (not warranty covered). Once the sensor fibre is correctly attached, the system will itself determine the number of sensors connected and the sensor status (see section 2.2.1). For specifications of the FBG sensors, see section 2.1.1. In standard operation mode, the SwitchedGator is pre-configured to run at 1, 5, 10 or 19.23 kHz sampling rate.

3.2 Software Installation

When the SwitchedGator is USB-connected for the first time to a computer, the required FTDI driver will be installed automatically (internet connection required, or install manually from the USB stick provided). The SwitchedGator will generate and stream data as soon as it is switched on.

The SwitchedGator product comes with a basic Windows OS software tool that allows visualization of the sensor status and CoG values, and CoG data storage (See section 4.1). The software suffices for most user applications, but the user is free to implement their own signal processing, based on the programmer references in Section 4.2. Simply follow the instructions of the installer to install the software. It might be needed to run the installation file as administrator.

If you would like to make use of a different programming environment (e.g. Python, LabVIEW), basic information can be supplied on the communication, drivers and data stream format. Technobis does not, however, support or provide any guarantee on implementation functionality.

For more information, updated news or further support, please contact us (info@technobis.com)

3.3 Unit Conversion

The central wavelengths (CoG bit numbers) that are generated by the SwitchedGator are absolute, calibrated central wavelengths in the operating range of the SwitchedGator. To make full use of the available 18 bit register, we defined the following conversion which can be used to determine the actual central wavelength λ_{CW} in nm.

$$\lambda_{CW} \text{ (nm)} = 1514 + \text{CoG_bit} / (2^{18}) * 72$$

In order to determine the strain ε or temperature change ΔT induced on an FBG sensor, one first has to know the default central wavelength value[†] (unstrained / room Temperature) for the particular sensor, defined as λ_0 . The relation between wavelength and strain and temperature is then as followed:

$$\frac{\Delta \lambda}{\lambda_0} = (1 - p_e) \cdot \varepsilon + (\alpha_A - \alpha_n) \cdot \Delta T$$

Here p_e is the strain-optic coefficient (0.22 for a glass fiber), ε the strain, α_A the thermal expansion coefficient, α_n thermo-optic coefficient and ΔT the induced temperature change. For a bare glass fiber the temperature dependence $\Delta \lambda / \Delta T$ is typically in the order of 10 pm/°C at 1550 nm wavelength.

[†] The central wavelength and strain conversion are implemented in the demo software as options for the plots.

4 Software guide

This chapter provides detailed information on the software provided with the SwitchedGator product and background information for software programmers regarding the data transfer format.

It is our vision to provide an open platform for the software implementation to develop a broad scale of implementations and specific applications. We encourage users to explore the available features and share implementations. Please contact us for updated information on the latest software releases and user examples. The source code for the demo software is available on request.

4.1 Demo Software

Standard data acquisition software is provided with your SwitchedGator product, which can be found on the USB-stick, delivered with the system. It might be needed to run the installation file as an Administrator. The software is developed for the entire Gator product line, so first the proper system type should be selected.

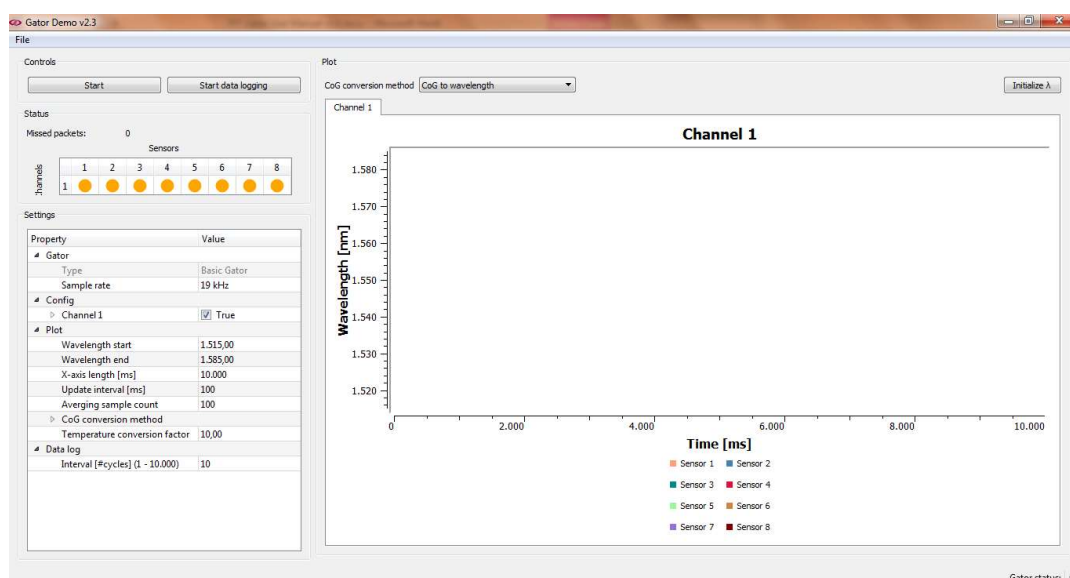


Figure 6: Screenshot of the demo software provided

Before starting the software, the SwitchedGator should be connected via USB and switched on.

Upon starting the program, the default settings are loaded. First step is to load the predefined settings for the interrogation of the connected FBG arrays, if you have defined these earlier (INI file). Otherwise take some time to manually configure the desired settings.

4.1.1 Settings

4.1.1.1 Switch settings

- Start and end channel
- View time per channel (in μs integers), min 2000, max (16.777.215 μs), default is 5000 (5 ms)

4.1.1.2 Sensor Configuration

- Select the channels which should be active in the software
- Set the number of expected FBGs,
- If applicable, name channels and individual sensors as required; otherwise the default name will be used.

4.1.1.3 Data Log Configuration (DATALOG_INTERVAL)

- Select data storage interval. Every interval, it will save an entire switch sequence (sum of channels times view time + 1 ms per switch action). If the defined interval is shorter than the switch cycle time, it will simply save all the data.

4.1.1.4 Plot Options

- Data averaging factor
- CoG data conversion method
 - Default: Wavelength (nm)
 - Strain (microstrain)
 - No conversion (CoG bit level)

Once the settings are defined, they can be saved into a configuration INI file, and recalled at any time.

Only when one or more sensors are connected on the selected optical channel, CoG data will appear on the graph.

4.1.2 LED Panel Indications

The LED panel is configured to provide active information on the FBG status on each active optical channel. The color indication is as followed:

- Green: FBG expected and observed correctly
- Orange: FBG expected but not observed
- Purple: No (extra) FBG expected, but observed
- Red: FBG present but not ok (saturated signal or spectrally too close to another sensor detected)

NOTE: The SwitchedGator does not discriminate which sensor is missing/additional; it merely detects the number of FBG peaks it observes and labels them 1-N, in increment FBG wavelength order.

4.1.2.1 Further Indicators

Missed packets: Counter of the number of data packages (single gator samples) missed in the acquisition (i.e. in the transport over USB).

4.1.3 Plot Options

The functionalities and settings for the graphs are as followed:

- Each optical line has its own graph in a tab into which the collected data is added
- Drag left in the plot to select a new y-scale range, right click to go back to default scale
- Alternatively select the plot start and end wavelength (in Default Wavelength axis option only).
- In default setting, the central wavelength of the sensors are shown.
- Relative settings can be monitored (microstrain level) and nulled with the < initialize λ > button.

4.1.4 Data Storage Format

The software also allows for data logging onto the hard disk. Every time a log is initiated, a file is created. Every 10 MB of data, a new file is created. A warning is given when only 250 MB of empty storage is left on the hard disk and data storage stops after clicking OK.

The stored data is in comma-separated (.csv) format and contains the following information:

- Header with settings as in the used configuration
 - FBG names as configured
- Data in format:
 - Timestamp
 - Sequence number counter of SwitchedGator samples
 - system status (1= ok, 0= not ok)
 - TEC status (1= ok, 0= not ok)
 - Missed frames: Cumulative missed packets counter
 - Channel, Optical channel the sample is taken from (1-8)
 - Sensor 1, Centre of Gravity bit level of first sensor observed (lowest wavelength FBG)
 - Sensor 2, CoG of second FBG
 - Etc. or 0 if no sensor is present

The SwitchedGator scans the optical spectrum for peaks above a certain threshold starting from low wavelength (1515 nm), thus numbering the sensors with increasing central wavelength.

4.2 Programmer's guide

4.2.1 USB Data output format

As soon as the SwitchedGator is switched on, sensor data is being created and transferred over the USB 2.0 connection. At an interval rate determined by the SwitchedGator sampling rate (standard 19.23 kHz, lower upon request), series of data sets (39 bytes per sample) are transferred.

The USB device has two virtual ports:

- Port A: 245 asynchronous FIFO mode, accessible using the D2xx.dll of FTDI
- Port B: normal UART, accessible as COM port in windows OS.

Port A is used by the switchboard to send out the sensor data. Prior to the sensor data a header is inserted with a synchronization sequence, a version number, a 16-bit packet counter and a 32-bit timestamp with a resolution of 1 μ s. Every 1/19.23 kHz (or slower as set by the SwitchedGator) a new frame is sent to the USB interface.

The FPGA firmware includes a sequencer for switching between the optical channels. The sequencer can be programmed via USB port A by the software. The following items can be set:

- Mode 00 or 01, mode 0 is manual (via gpio inputs, default) mode 1 is sequencer enabled
- Start Channel (0-15)
- End Channel (0-15)
- ChnSwTime: these are 16x 24-bit timing registers with a resolution of 1 μ s (= 71 min max). Through these registers, the sampling time (time between switching to the next fiber) for each channel is set separately.

Note : When you select mode 1, and set ChnSwTime in all registers to 0 and Start and End Channel register the same value you can " manually " select the fiber channel via the USB interface.

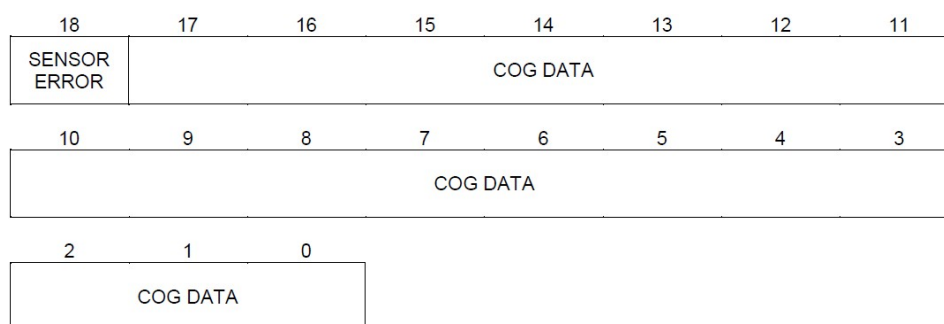
4.2.2 Sensor status word

18	17	16	15	14	13	12	11
SEQUENCE NUMBER		SWITCH STATE			TEC TEMP OK	SENSORx OK	
10	9	8	7	6	5	4	3
SENSORx OK						NUM SENS FOUND	
2	1	0					
NUM SENS FOUND		1					

- Sequence number
 - These 2 bits indicate the sequence number (18,17)

- SwitchState
 - These bits indicate the channel (16,15,14) (000 = channel 1, 001 = channel 2, etc)
- TEC Temp ok
 - This bit represents the TEC temperature good flag ('1'=OK).
- Sensor_x OK
 - These bits indicate if the sensors are working with the established parameters ('1' = OK, '0' = error or no sensor).
- Num sens found
 - These bits indicate the number of sensors found (0 – 8). In case too many sensors are found, the output will be 0xF.

4.2.3 Sensor data (1-8) words



- Sensor error
 - This bit indicates a sensor error (sensor out of range, saturated or sensors too close together). '1' = error, '0' = no error
- CoG data
 - This field contains the CoG sensor output data which is calculated by the internal algorithm. If a sensor error is active, all bits are '1' and in case no sensor is found '0'.

Contact Technobis for further information or support.

Certifications and Compliance



Hereby, Technobis fibre Technologies, declares that the SwitchedGator system is in compliance with the essential requirements and other relevant provisions of the Directive 2014/30/EU of the European Parliament and of the Council.

This equipment can be used in all countries that are member of the European Union and that are member of the European Free Trade Association.

The test reports and D.O.C. can be requested by e-mail: info@technobis.com

Test report number for the assessment according to Directive 2014/30/EU (EMC).

End of life policy (WEEE)



Technobis Fibre Technologies complies with the Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU and honors its obligations under this directive. This product is marked with the symbol below, indicating that one must not discard the product with domestic household waste. Please contact your local representative for disposal in accordance with local law.



RoHS compliance

Technobis declares that the SwitchedGator product is in accordance with to the RoHS Directive 2011/65/EU, which restricts the use of hazardous substances in electrical and electronic equipment.